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Flume Collecting: A Rediscovered Insect Collecting Method, with Notes on Insect Extracting Techniques

Jeffrey A. Halstead and Robert D. Haines

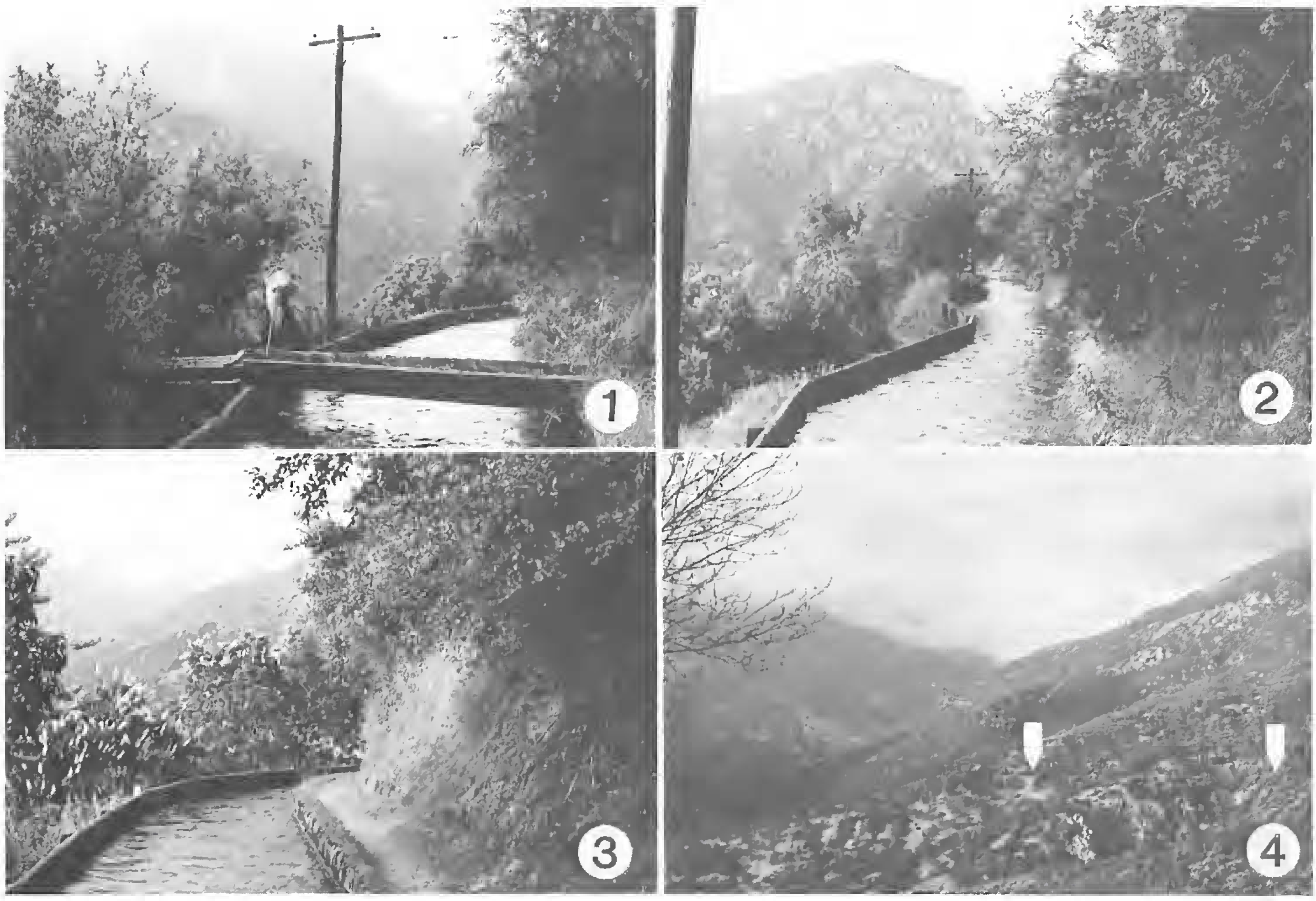
Department of Biology, California State University Fresno, Fresno, California 93740; present address 2110 N. Hayes, Fresno, California 93722. Tulare County Agricultural Commissioner's/Sealer's Office, Visalia, California 93291

Abstract.—The use of flumes (i.e., a channel for the transportation of water) as a collecting source is discussed. A five mile long flume near Ash Mountain, Sequoia National Park, Tulare County, California is described, along with techniques used to collect and extract insects from flume debris. This flume, utilizing the various collecting techniques described, has produced an astonishing diversity and abundance of insects. In the 1930's and 1940's, much of the material from this site was cryptically labeled and thus type locations and basic locality data were misleading and difficult to pinpoint. Notes on such labels are presented.

Flumes, as a collecting source, were heavily utilized in the 1930's by such collectors as Dr. E. C. Van Dyke, Mr. F. T. Scott and Mr. R. S. Wagner. Their work greatly added to the knowledge of California species of Coleoptera, many of which were new or rare species collected from flumes. The latter two researchers collected almost exclusively from flumes in the Sierra Nevada foothills. The function of these flumes is water diversion from rivers and streams for the generation of hydroelectric power and public uses. These flumes act as a giant moving pit trap, catching insects that either blunder in or are drawn to a water source.

Two basic techniques were used to collect these insects: (1) watching the water surface as material approached and netting what was seen and (2) pulling out and sorting through debris that had accumulated at the end of the flume prior to the water being run through a powerplant or into a holding pond. The first technique was time consuming, limited to those insects that fell into the flume that day, and yielded mostly larger species. The second technique yielded much better results (i.e., greater diversity and abundance), but required the use of some sort of debris collection device.

All three of the previously mentioned collectors made use of a flume located in Tulare County, California on the Middle Fork of the Kaweah River, initiating at Potwisha Campground in Sequoia National Park and terminating on the hillside south of the Ash Mountain Park Headquarters. This flume (Figures 1–4) flows through approximately five miles of Chamise Chaparral and Foothill Woodland plant communities at an elevation of 660 m (2200 ft.) and empties into a large (20 m × 60 m) forebay (Figure 5) whose teardrop shape and exposure to prevailing breezes promotes clockwise surface currents. A wooden boom (10 cm × 15 cm × 3.5 m) projecting into these currents traps and accumulates the floating debris



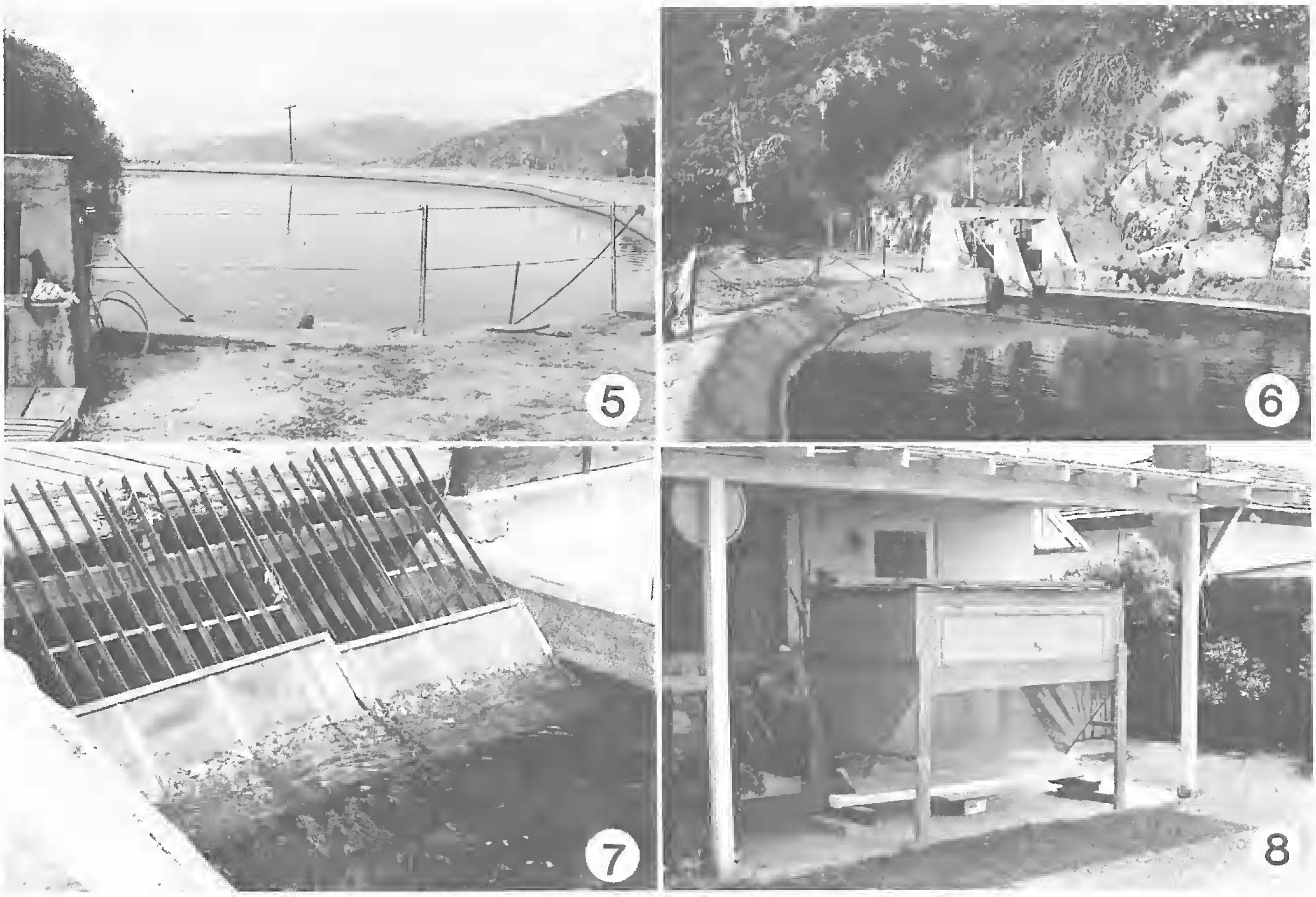
Figures 1–4. Figs. 1–3. Typical sections of the Ash Mountain. Kaweah Powerhouse #3 flume, illustrating adjacent and overhanging vegetation and rugged terrain of Sequoia National Park (June). Fig. 4. The flume, denoted by arrows, curves along hillsides of Chamise Chaparral and Foothill Woodland habitats at 660 m (2200 ft.).

(boom-trap method) (Figure 6). The researchers would scoop out the debris and spread it over the ground for examination.

The Ash Mountain flume is unique in comparison to others in the Kaweah area and throughout California. In addition to having a built-in debris accumulating feature (i.e., the boom), the edge of the flume throughout most of its length is at ground level. This greatly enhances the chance of insects falling into it—in comparison to flumes that are supported by trestlework 1 to 7 m above the ground. The native flora adjacent to and overhanging the flume's edge is another factor contributing to the great diversity and abundance of insects collected.

The early researchers labeled the material collected at the Ash Mountain flume in a variety of ways. Because of this, a number of type localities have been difficult to pinpoint. Examples of such labels are: near Postwisha, Sequoia National Park; Sequoia National Park, 500–2000 ft., Potwisha (Van Dyke); Kaweah; Sequoia National Park, 2000–3000 ft. (Scott); K.P.H.R.; Kaweah Powerhouse Reservoir; Kaweah (Wagner).

Some examples of type material collected from this site include: Coleoptera, Cerambycidae: *Ergates pauper* Linsley, *Paranoplium gracile laticolle* (Linsley), *Aneflomorpha california* Linsley = *A. parowana* Casey, *Neoclytus resplendens* Linsley, *Leptura sequoiae* (Hopping); Scarabaeidae: *Pleocoma tularensis* Leach,



Figures 5–8. Fig. 5. Overview of forebay from beside the entrance of the flume. Floating debris, having floated down the flume, can be seen on the forebay's surface. Fig. 6. View of forebay towards the entrance of the flume. The wooden boom, floating on the forebay's surface and extending from its edge, traps and accumulates debris which has floated down the five mile flume. Fig. 7. Window screen panels are inserted into the flume to trap and accumulate flume debris before it enters the forebay. Fig. 8. Berlese-photoattractive trap used to extract insects from the flume debris.

Coenonycha fusca McClay; Buprestidae: *Polycesta tularensis* Chamberlin, *Polycesta crypta* Barr, *Acmaeodera simulata* Van Dyke; Elateridae: *Euthysanius cribicollis* Van Dyke; Diptera, Acroceridae: *Ocnaea sequoiae* Sabrosky; Hymenoptera, Pompilidae: *Allaporus amabilis* Evans = *Pompilus (Aporus) smithianus* Cameron. The above information is presented so that researchers will have a clearer understanding of how and where such material was collected.

Beginning in 1982 a renewed effort was made to utilize the Ash Mountain flume facility by the authors, Dr. D. J. Burdick (California State University Fresno) and Mr. W. F. Peregrin (Fresno County Agricultural Commissioner's Office, Fresno, California). Initial efforts using the old technique of retrieving accumulated debris (mostly leaves) at the forebay yielded a great diversity and abundance of species. Insects are easily observed and collected from the drying debris as they dry their wings and/or move among the leaves. Dead insects are also found while sorting through the debris, commonly stuck to wet leaves.

The amount of debris collected by the flume varied with the season. The greatest accumulation of debris correlated with fall leaf drop. Two researchers during a typical 8 to 10 hour period can sort approximately 60 to 75 square meters (200 to 250 square feet) of debris, 2.5 to 5 cm (one to two inches) in depth. Because the flume is continually accumulating debris both throughout the day and the night, the day's collecting was usually terminated only by the lack of visibility (i.e., sunlight). Often, all of the debris which had accumulated behind the boom could not be sorted in a single day. Because this unexamined debris represented material which had floated down the flume that day (thus containing live insects) and was known to contain a good diversity and abundance of late-day and crespuscular species, the debris was sealed in garbage bags and transported to the laboratory for further treatment (see discussion under Insect Extraction Techniques).

While the boom trap method was successful in 1982 and early 1983, a large sandbar, which had accumulated over a number of years, began changing surface currents reducing debris accumulation behind the boom. As a result, the debris was patchily distributed over the forebay, reducing its availability. In order to collect the debris before it entered the forebay, window screen panels were inserted into the flume against an existing metal grating at its entrance into the forebay (Figure 7). The debris was removed from the screens and examined about every 30 minutes. During an 8 to 10 hour period, two researchers could collect and sort approximately 24 square meters (80 square feet) of debris. While some small (<1 mm) insects probably passed through, many were stuck to leaves on the screens. The small amount of debris examined (versus the boom trap method) improved collecting efficiency. Also, the insects collected on the screens were very active and easily detected.

The screens gave excellent results for material-of-the-day (including activity period information), but the accumulated debris behind the boom covered several days and nights, and in general, held a much greater abundance and diversity (including nocturnal species). At times, screening was not practical due to large amounts of leaves and/or algae which blocked flow through the screens. Though the sandbar was removed in 1985, the benefits of using screens for collecting material-of-the-day precluded abandoning this technique to return strictly to the boom trap method.

Another problem was encountered in the late Summer and early Fall of 1985. Due to a lighter than normal winter snowpack in the Sierras and a lack of substantial Spring rains, water levels in the Kaweah River dropped below diversion levels. While there had been temporary shutdowns in prior years for flume maintenance and sand removal, this was the most extensive dry period encountered by the authors, lasting from August through mid November.

Insect Extraction Techniques

1) Glass-topped Sleeve Cage.

Approximately 10 to 15 cm (4 to 6 inches) of debris was placed in each of two to three glass topped sleeve cages (0.6 × 0.6 × 1 m). An oscillating fan was used to move air through the sleeve cage(s) to dry the debris. A white light (60 watt bulb) was positioned on the top of each cage to attract insects. The cages were checked periodically for two days though insect activity rapidly declined after one day. Insects were removed with an aspirator or by hand. Cryptic species were commonly found on the bottom of the cage or among the debris. This technique was productive though limited by the amount of debris that could be placed in the sleeve cage(s). Also, the debris was difficult to dry and immediately started to decay.

2) Enclosed Malaise Trap and Tent trap.

To increase the amount of debris that could be handled at one time, an enclosed Malaise trap and tent trap were utilized. The enclosed Malaise trap (2 × 1 × 1.8 m) was set up outdoors. The bagged debris and/or debris that was first examined in the sleeve cages was placed inside the sealed trap the morning following the collecting trip. The warmth and drying effect of the sun immediately resulted in insect activity. Insects readily crawled up the sides of the trap, passed through an inverted funnel, and fell into an alcohol solution in the collecting head. The alcohol solution eliminated any damage to specimens. This technique was more productive and less time consuming than the sleeve cages. A major drawback was that insects which did not climb up the Malaise trap were not collected. Also, spiders occasionally spun webs at the entrance to the collecting head, but because of the great numbers of insects very few were eaten or deterred from entering the head.

The tent trap was devised to be used in the laboratory. This trap was a two-man tent (2 × 1.2 × 1 m) to which an alcohol-collecting head was attached by a fine mesh insect net. The debris was placed inside the tent on a 2.5 cm (one inch) chicken wire screen (1.2 × 1.8 m (4 × 6 ft.)) that sat on blocks 10 cm (4 inches) above the floor of the tent. An oscillating fan was run outside the tent's mesh door for about 6 to 12 hours. The screen aided the drying of the debris and also burrowing insects fell from the screen to the floor of the tent where they could be collected. Very little insect activity occurred when the fan was on; though once off, increased immediately. This technique was more profitable than the two previous techniques (especially because non-climbing insects were also collected). Again, minor spider problems occurred with the collecting head.

3) Berlese-photoattractive Trap (Figure 8).

This trap (2 × 1.2 × 1.5 m (6 × 4 × 5 ft.)) was the most productive and time efficient insect extracting method, utilizing the collecting principles of both a large Berlese funnel trap and a photoattractive trap. It consisted of a black plastic top, particle board sides with fine mesh windows, two flat internal debris trays (0.9 × 1.5 m (3 × 5 ft.)) made of window screening stacked 15 cm (6 inches) apart, and clear plastic lower sides which funnel downward into a plastic rain gutter filled with 5 to 7.5 cm (2 to 3 inches) of super saturated saltwater solution or ethylene glycol.

Upon returning home from the day's collecting trip, about 5 to 10 cm (2 to 4 inches) of debris was placed on each tray. A light and fan were run outside the trap's windows until early morning. Light seeking insects were immediately attracted to the mesh windows and clear plastic funnel. Those which burrowed into or through the debris eventually fell off the screens into the rain gutter. With the coming of daylight, the black plastic top readily heated the inside of the trap, thus forcing insects downward. The windows were occasionally fogged with a quick knockdown pyrethroid. The debris was left in the trap for about one week by which time most insects had fallen into the rain gutter. One last heavy fogging killed any remaining survivors. The debris trays were removed and the inside of the trap was washed with water to remove any clinging insects. The resulting rain gutter full of insects was then screened and the insects preserved for future sorting.

Though much of our material is still unmounted, detailed examination of some groups by authorities have revealed many new species, male/female associations, range extensions, and rarely collected species (not to mention the great diversity and abundance of the more common species). Most of this material has been deposited in the California Academy of Sciences, San Francisco; California Collection of Arthropods, California Department of Food and Agriculture, Sacramento; and the Canadian National Collection, Ottawa.

Examples of species diversity for some of the families reviewed are (# of genera, # of species): Coleoptera, Buprestidae (11, 40), Cerambycidae (43, 61), Chrysomelidae (47, 57); Hymenoptera, Chalcididae (12, 30), Chrysididae (9, 23), Dryinidae (12, 23), Eumenidae (9, 18), Mutillidae (9, 21), Pompilidae (17, 41), Sapygidae (1, 5), Sphecidae (22, 40); Diptera, Acroceridae (6, 12). Examples of some of the rare families encountered are: Coleoptera, Amphizoidae (1, 1), Cupedidae (1, 1); Hymenoptera, Chalcedectidae (1, 2), Cimbicidae (1, 1), Eucharitidae (1, 1), Evaniidae (1, 1), Leucospididae (1, 1), Orussidae (1, 1), Sierolomorphidae (1, 1), Stephanidae (1, 2); Neuroptera, Mantispidae (3, 3).

As illustrated by this preliminary data, when the appropriate techniques are utilized, flume collecting can be an extremely successful method; giving the collector access to rare species that would be otherwise unavailable. A great deal of seasonality and daily activity information can also be gathered using these techniques. By the publication of this paper we hope to provide an understanding of where and how the Ash Mountain flume specimens have been collected and also to encourage the use of flumes as a collecting source.

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